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A phyto-geographic sketch of extreme southeastern Pennsylvania

JOHN W. HARSHBERGER

TOPOGRAPHY

The area considered in this phyto-geographic survey comprises the region of Pennsylvania drained by Wissahickon creek, lower Schuylkill river, Cobbs creek, Darby creek, Crum creek, Ridley creek and Chester creek, extending to the divide between Chester creek and the lower Brandywine. It is part of the well-characterized Piedmont plateau in the Atlantic drainage system, and comprises the district situated south and southeast of the range of hills formed by the Laurentian syenites. All of the streams mentioned, with the exception of the Wissahickon, the Brandywine, which heads in the low limestone of the Chester valley, and the Schuylkill, which rises in the mountains, take their rise to the east and southeast of the divide formed by the range of hills that owe their origin to the resistance of the Laurentian syenite rocks to erosion, from the earliest geologic time. The Wissahickon, the Schuylkill and the Brandywine flow from the low limestone Chester valley and through gneiss gorges on their way to the Delaware river. In the case of the Wissahickon, the act is startlingly bold, because accomplished by a small stream.

It may be stated here briefly that when the gorges of the Wissahickon, the Schuylkill and the Brandywine were made, Chester valley was at a much higher level. Its soft limestone rocks were dissolved faster than the gneiss, hence the width of the Chester valley and other limestone valleys compared with the narrow valleys cut in the harder gneissic rock. Cobbs, Darby, Crum, Ridley and Chester creeks rise upon, or on the eastern slopes of the Laurentian ridge which extends in a general southwestern direction from beyond the Delaware at Trenton to West Chester, Chester county, Pennsylvania. This ridge, reaching a general elevation of 300–500 feet, marks the boundary of the limestone Chester and Whitemarsh valleys, crosses the Schuylkill below Norristown and widens in Chester county into a confused range of hills. The streams, just mentioned, flow generally southeastward into the

Delaware river, striking across several geologic formations. The Laurentian syenites are cut into by the headwater tributaries of these streams, which make gorges in the newer gneissic rocks of the region, finally flowing across the alluvial plain found along the Delaware river.

The shorter streams with less volume of water have not cut across the Laurentian divide, but they are and have been constantly at work widening and deepening their gorges, so that in the last few miles of their courses they often run practically at base-level, as indicated by the sluggishness of their flow. During their existence, these creeks, as well as the master-streams mentioned above, have been subjected to various vicissitudes through oscillations of the earth's surface. Several times their lower stretches have been subjected to depression and elevation. During periods of depression, their mouths have been drowned by the encroachment of the sea upon the preceding land-surface, the Delaware river becoming an estuary of the Atlantic ocean, with the deposit of sediments in the form of mud, sand and gravels. Nevertheless the streams of the region have been constantly at work reducing the country to a peneplain, eating away the sand and gravel deposited during submergence and leaving undisturbed patches to tell the tale of their former existence. During periods of subsidence, erosion has been less active, but during long periods of elevation the streams have been reawakened and started afresh into active earth-leveling.

The Piedmont plateau and the alluvial coastal strip in southeast Pennsylvania were, with the similar region in New Jersey, subjected to movements of the earth's surface. The following may be recognized as of importance in the consideration of the region from a phyto-geographic aspect:

1. The post-Triassic uplift and the subsequent development of the Schooley peneplain.
2. The Cretaceous subsidence and deposition.
3. The post-Cretaceous uplift.
4. The Miocene submergence and the deposition of the Miocene beds.
5. The post-Beacon-Hill submergence and the development of the pre-Pensauken peneplain.

6. The Pensauken submergence and the deposition of the Pensauken formation.

7. The post-Pensauken uplift and the erosion accomplished between this uplift and the last glacial epoch.

8. The last glacial epoch.

During the Pensauken submergence the land was depressed to such an extent as to drown the Delaware river at its lower end, allowing the sea to pass up its valley and over the peneplain which had been developed during the previous cycle of erosion, so that a broad sound was formed which connected Raritan bay with Delaware bay. The Delaware river entered the Pensauken sound at Trenton, and the Schuylkill river, Cobbs, Darby, Crum, Ridley and Chester creeks emptied into this sound, having their lower portions drowned through this submergence.

The mouth of the Delaware river during the post-Pensauken uplift was transferred to Delaware bay, the creeks above mentioned assumed their old relationship to the country and began again actively to erode their basins. This cycle of erosion lasted until the ice of the last glacial epoch invaded the northern portion of the state. The topography of the region under consideration was changed but little and what changes were brought about were due to the deposition of drift, which was far from uniform.*

These topographic and geologic facts have been mentioned somewhat at length, because they have strikingly influenced the vegetation of the country since Cretaceous times, when we have a great and sudden inswarming of the higher plants of modern types, at the close of the lower Cretaceous. The great feature of this period was its dicotyledonous forests. Thus the following genera of trees found in southeast Pennsylvania to-day date from the Cretaceous period: *Fagus*, *Liquidambar*, *Liriodendron*, *Salix*, *Quercus*, *Castanea*, *Betula*, *Alnus*, *Platanus*, *Sassafras*, *Diospyros*, *Juglans* and *Hicoria*. The botanical character of the Amboy clays of coastal New Jersey, influenced by the changes of elevation described above, will be seen from the following brief synopsis.†

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* *Cf.* Salisbury, R. D. The physical geography of New Jersey. Geol. Surv. N. J. 4: — 1898. — Heilprin, A. Town geology. — Leslie, P. Final report, Pa. Geol. Surv. I. — Rand, T. D. Notes on the geology of southeastern Pennsylvania. Proc. Acad. Nat. Sci. Phila. 1900: 160–338. 1900.

† Dawson, J. W. The geological history of plants. 204.

The angiosperms form about seventy species, which include three of *Magnolia*, four of *Liriodendron*, three or four of *Salix*, three of *Celastrophyllum*, one of *Celastrus*, four or five of *Aralia*, two of *Sassafras*, one of *Cinnamomum*, one of *Hedera* (with leaves that are apparently identical with those described by Heer as belonging to *Andromeda*), *Cissites*, *Cornus*, *Diospyros*, *Eucalyptus*, *Ficus*, *Ilex*, *Juglans*, *Laurus*, *Menispermites*, *Myrica*, *Myrsine*, *Prunus*, *Rhamnus* and others.*

A statement of the above facts is proof that during the Tertiary period and up to its close a dense forest existed in north temperate and arctic latitudes. The northern portion of this forest and the tenderer species unable to withstand the nipping frosts were exterminated with the advance of the glaciers. South of the great terminal moraine, which reaches as far south as the Ohio river, but separated from it by a zone tenanted by arctic-alpine plants and other boreal species now found on mountain-tops and in the Hudsonian and Arctic belts of North America, the original Tertiary forest, minus such genera as *Eucalyptus*, *Ficus*, *Cinnamomum*, etc., persisted, reaching its greatest denseness in the region drained by the Tennessee river and its tributaries. One tongue of this forest of less denseness probably reached in a northeastward direction, as far north as a line following the windings of the west branch of the Susquehanna river to the Blue Ridge, thence along the Blue Ridge to the Schuylkill river, thence across to the southeast side of Great Valley and following the hills on the south side of Great Valley to the Delaware river.

Arbitrarily considered, all of the territory above this line and between it and the terminal moraine was a country influenced by the glacial cold. All of the country south of it, protected by the Allegheny mountains, the Blue Ridge and other ranges of hills to the eastward of the Schuylkill river, was covered by a forest composed in the main of those species of trees, not destroyed by the glacial cold, that had existed in this region, and also in the far north prior to the advent of the last glacial epoch. Comparing the northern remnant of the magnificent Tertiary forest with the southern remnant of this forest in the region drained by the Tennessee river, and in the southern Appalachian mountains, generally speaking, it lacks many of the peculiar arboreous and herbaceous species which characterize the flora of the south and which have their nearest living representatives in the flora of eastern China and Japan.

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* Knowlton, F. H. A catalogue of the Cretaceous and Tertiary plants of North America. Bull. U. S. Geol. Surv. No. 152. 1898.

With the retreat of the great ice-sheet, the region once covered by the ice was restocked by trees and herbs derived from three main sources of supply: (1) Scandinavia, (2) Hudsonian zone of the Glacial period, (3) Appalachian forests (north and south). The Scandinavian plants migrated eastward during the inter-glacial period and tenanted the moraines, nunataks and arctic strip of territory throughout the later glacial epoch. With the retreat of the glaciers, they migrated northward with the ice sheet, or they persisted on the tops of high mountains which existed as nunataks during the ice age, or they remained as boreal islands in sphagnum-bogs, or in cold and shaded ravines. A northward migration of Hudsonian species and of Appalachian species in concentric waves also took place at the close of the Glacial period.*

The action of the several uplifts and depressions of the earth's surface described was most profound upon this forest, the history of which has been traced. With every submergence of the lower portions of the creeks of the region and of the Delaware river, the forest in the area of submergence was destroyed, or if existing on the higher grounds, was subjected to such extensive changes of level, as to highly modify its character and the distribution of the component species. Many species were crowded together by the change of level and the wearing away of the strata to which they had become adapted, for "if we suppose the earlier Mesozoic uplands to be the seat of the existing dicotyledons, then by the lowering of the surface by gradual consumption of the interstream areas, these forms must have been brought into conflict with the flora of the lowlands and thereby forced into a contest for supremacy."†

Xerophytes of the hillsides and rock exposures (such as serpentine)* are replaced by mesophytes, which thrive in rich alluvial soils ; mesophytes, by the wearing away of the soil and the formation of cliffs, by xerophytes, such as exist on the serpentine barrens of southeast Pennsylvania ; hydrophytes replace mesophytes, when an area becomes too wet for the tenancy of ordinary plants. Thus, if we apply such principles to the study of our region, southeastern Pennsylvania, the dry ground formed by the post-Cretaceous uplift was the seat of a dense mesophytic forest, by erosion mesophytes of the plain were replaced by xerophytes of the hillside, and by a still more pronounced base-leveling process, the xerophytes were again replaced by mesophytes. When the submergence occurred and the forest was drowned, a series of hydrophytes filled the tidal estuaries to be replaced by terrestial plants at the next uplift.

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* *Cf.* Adams, C. C. Post-Glacial origin and migrations of the life of the northeastern United States. Jour. Geol. 1 : 303. S 1903.

† Woodworth, J. B. The relation between baseleveling and organic evolution. Am. Geol. 14 : 231. O 1894.

Shull † gives an interesting case in point. The distribution of *Isoetes saccharata* Engelm. along Chesapeake bay is explained by the geomorphic movements of the coastal plain. The present elevation of land is such that the water of the bay is fresh about ten kilometers below the mouth of the Susquehanna river. During periods of greater elevation the water was fresh farther to the south. When the land was so elevated that the water was fresh at the mouth of the Potomac river, favorable habitats along the shore of the bay must have been occupied by the progenitors of the colonies of *Isoetes saccharata* which now occur in the upper estuarine portion of the tributary rivers. As the land sank and the rivers were ponded farther and farther from their mouths, new areas became adapted to the growth of *Isoetes*, and new colonies were formed. Simultaneously the colonies furthest down stream were destroyed by the advance of salt water. In this way there came to be, instead of a single colony or group of colonies at the head of Chesapeake bay, as many distinct colonies as there were ponded tributaries. So long as the land continued to sink, the successful reproduction was on the up-stream side, and destruction followed *pari-passu* on the down-stream side until the present condition of widely separated colonies was brought about. In periods of elevation the reverse process must have taken place, and the many distinct areas must have been merged again into one. As we find *Isoetes saccharata* Engelm. nowhere else than in Chesapeake bay and *Isoetes riparia* Engelm. nowhere else than in Delaware bay, it seems fair to assume that the physiographic changes mentioned above as controlling the distribution of the former species have influenced the distribution of *Isoetes riparia* along Delaware bay in a somewhat similar manner.

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* Harshberger, J. W. Flora of the serpentine barrens of southeast Pennsylvania. Science, II. **18** : 339-343. 11 S 1903.

† Shull, G. H. Geographic distribution of *Isoetes saccharata*. Bot. Gaz. **36** : 199. S 1903.

We can picture to ourselves the manner in which the area uplifted from the water was tenanted by various species of dry-land plants. The process may have been gradual, permitting the gradual adjustment of the newly implanted vegetal covering, or it may have been sudden, followed by an inrush of species. Lange * describes an interesting case, illustrating the latter process.

The establishment of vegetation upon the flood-plain of the Delaware river may best be studied on islands formed by the deposition of silt about some obstacle in the river. A bar originates. The first vegetation consists largely of annuals, then come willows, and finally a characteristic flood-plain forest. The red maple (*Acer rubrum*) appears, then poplars and the ash (*Fraxinus Americana*). Gradually the plain becomes dry enough to permit the development of a true mesophytic forest. Some such stages were passed through by the vegetation of southeastern Pennsylvania with each uplift following a process of depression. The same forces are at work now that were active in past geologic time, and the same laws are in operation which then controlled the distribution of plants.

The history of the upland plant associations is somewhat different from that of the lowland. In tracing the genetic development of these associations, we must consider especially the vegetation of the creek ravines. Cowles † has described the origin of the vegetation of clay ravines. None of this class of ravines are found typically developed in southeastern Pennsylvania. Rock-gorges are common and are occupied by all of the streams that drain the region under consideration. The physical nature of the gneissic and syenitic rocks excludes landslide action and lateral cutting is relatively slow, as compared with ravines formed in clay. Thus the conditions are much more favorable for the growth of plants in a rock-gorge than in a clay ravine. Rock-gorges are shady and often the rocks drip with water and are, therefore, carpeted with mosses, ferns and liverworts. Shade-loving plants abound, whose leaves are broad and thin. The stages of development pass more slowly in rock-gorges. With the gradual widening of the cañon, however, the character of the flora undergoes a slow change, so that the vegetal covering is never stable, but constantly shifting, now of one appearance and with the lapse of time and change of physiographic conditions of another.

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* Lange, D. Revegetation of Trestle Island. Minn. Bot. Stud. 2: 621. 1901.

† Cowles, H. C. The physiographic ecology of Chicago and vicinity. Bot. Gaz. 31: 88. 1901.

The character of the soil conditions, therefore, influences the particular kind of vegetation, so that we may have with the same exposure of light, heat and moisture a different flora, if the superficial soil deposits are different. Recent work * appears to show that, contrary to opinions that have long been held, there is no obvious relation between the chemical composition of the soil as determined by methods of analysis used and the yield of crops, but that the chief factor determining yield is the physical condition of the soil under suitable climatic conditions. The rainfall determines the productiveness of a country. Temperature and rainfall together are one of the most important natural resources of a country.

Clearly, therefore, the distribution of species does not depend so much upon the chemical character of two different strata,† but it is because one geologic area has advanced further in its life history than the other. The vegetation, for example, of a clay hill to-day will be seen on a sand hill in the future. The laws that control changes in the plant covering of a country are, therefore, plainly physiographic. Wherever hills are being eroded, valleys widened, rivers deepened, waterfalls eliminated, lakes filled, or coastal plains enlarged, there must be a constant change in the plant societies, or a succession in definite order of plant groups.

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* Whitney, M. and Cameron, F. K. The chemistry of the soil as related to crop production. U. S. Dept. Agric. Bureau Soils, Bull. 22 : — 1903.

† Cowles, H. C. The influence of the underlying rocks on the character of the vegetation. Bull. Am. Bureau Geog., Je–D 1901.

PLANT FORMATIONS AND ASSOCIATIONS

Southeastern Pennsylvania is a region of hills, of valleys, of meadows and of rocky ravines sloping down in general from the Laurentide hills to the Delaware river.

It represents an original table-land whose general elevation was about 500 feet above tide-level. Originally the surface, hills as well as river-plain above the fresh-water marshes which line the Delaware river, was covered by a dense forest of trees. Since the settlement of the country the most desirable land has been under cultivation, and many flourishing manufacturing towns, as Philadelphia, Chester, Conshohocken and Norristown, are found partly on the river-plain and partly situated on the rolling hills formed by the newer gneissic rocks. Culturally speaking, several kinds of land may be distinguished, such as river-land, marsh-land, city- and town-land, farm- and cultivated land, uncultivated woodland, uncultivated barren land, and abandoned farm-land.

Botanically considered, the following ecologic plant formations and associations may be distinguished, and these are determined approximately by the character of the areas above mentioned.

A. UNCULTIVATED.

AQUATIC-PLANT FORMATION.—The rivers and creeks of our region, especially in their lower courses, have smooth stretches of water in which grow a number of aquatic species. These species in the tidal estuaries are usually of the larger sort and are well adapted to grow in water where there is a change of level between low and high tide of about three feet. In many of the streams, the tidal flow is of considerable strength and the current established, therefore, influences the distribution of the vegetation to a marked extent. Where the flow is less strong and swift, there the material in the form of mud and silt is deposited and upon this alluvial material aquatic plants take root and gradually raise the level of these areas by catching and holding fresh deposits of silt. The result is a tidal marsh intersected by numerous meandering channels through which the tidal water ebbs and flows.

In the Schuylkill river above the dam at Fairmount is such a deposit of silt. *Vallisneria spiralis* L. forms a pure association of such extent as seriously to interfere with the navigation of the river by pleasure craft (*Vallisneria* association). In some of the smaller streams and in ponds formed in artificial depressions, *Philotria Canadensis* (Michx.) Britton (*Elodea Canadensis* Michx.) abounds. A fine growth of this plant, the water-weed, is found in an abandoned quarry-hole at Leiperville, Pa., and another in a small stream near Horticultural Hall, Fairmount Park (*Elodea* association). The spatterdock, *Nymphaea advena* Soland. (*Nuphar advena* Ait. f.) is probably the commonest aquatic plant that grows in the tidal portions of the streams of southeast Pennsylvania. It covers acres of mud ground and stretches as a pure association for miles along the Delaware and Schuylkill rivers (*Nuphar* association). Associated with it in shallower water the pickerel-weed, *Pontederia cordata* L., abounds, forming in places pure associations. This interesting plant with trimorphic flowers is most abundant on the New Jersey side of the Delaware river (*Pontederia* association). The duckweeds are found in the ditches and ponds of the region. This is true especially of the district in South Philadelphia known as the Neck. The agricultural land, kept in a high state of fertility by the application of city manurial waste, is intersected by numerous ditches where abound *Spirodela polyrhiza* (L.) Schleid., *Lemna minor* L., *Wolffia Brasiliensis* Wedd., and *Wolffia Columbiana* Karst. (*Lemna* association). *Orontium aquaticum* L., the goldenclub, is also a plant that forms in places ecologic groups (*Orontium* association). The water-chinquapin, *Nelumbo lutea* (Willd.) Pers., twenty-five years ago existed in the region of the "Neck." With the spread of the city southwest, the plant was destroyed.

POND-PLANT FORMATION. — There are no ponds or lakes of any size natural to southeastern Pennsylvania; all that now exist are artificial. Some of them occupy depressions from which clay has been taken for bricks; others occupy the bottoms of rock quarries, while still others have been formed by the damming of streams. The only natural ponds are of small size and are rather pools formed in a depression near some perennial spring. The ecologist finds in such natural pools, or along their edges, a collection of species that seem to give character to them, such as *Chrysosplenium Americanum* Schwein. (*Chrysosplenium* association), *Veronica Americana* Schwein., *Typha latifolia*

L., *Philotria Canadensis* (Michx.) Britton, *Acorus Calamus* L., *Iris versicolor* L., *Myriophyllum verticillatum* L., *Spirodela polyrhiza* (L.) Schleid., *Cardamine bulbosa* (Schreb.) B. S. P. (*C. rhomboidea* DC.), *C. rotundifolia* Michx., *Caltha palustris* L., *Myosotis palustris* (L.) Lam., *Roripa palustris* (L). Bess. (*Nasturtium palustre* DC.), *Roripa Nasturtium* (L.) Rusby (*Nasturtium officinale* R. Br.) (*Nasturtium* association), *Isnardia palustris* L. (*Ludwigia palustris* Ell.) and various algae, viz., *Spirogyra*, *Hydrodictyon*, *Conferva*, *Nitella*, *Oedogonium*, *Volvox*, *Euglena* and *Mesocarpus*.

TIDAL-MARSH-PLANT FORMATION. — This formation was studied along the Delaware and at the mouths of the Schuylkill river, Crum and Darby creeks. The most satisfactory place to study the ecologic disposition of the plants is at the mouth of Crum creek, where the botanist can take advantage of a wooden footbridge (two thousand feet long) constructed to connect a lighthouse with the mainland (FIG. 1). The tidal marshes have been formed by a variety of contributing forces. Material brought down by the rivers has been sorted and distributed over the tidal areas by the tides and currents of the streams that meet here. The location of these deposits and their superficial extent has depended upon the character, force and direction of the currents. Elaborate plans are in existence showing the currents of all the navigable streams in southeastern Pennsylvania. These may be consulted at the office of the United States engineer in charge of harbor improvements. The material is too abundant and the details too specialized to present in a paper of this character.

The banks of the streams influenced by tidal action are lined by thickets composed of *Platanus occidentalis* L., *Gleditsia triacanthos* L., *Alnus rugosa* (Du Roi) K. Koch, (*Alnus serrulata* Willd.), *Acer rubrum* L., *Salix alba* L., *Liquidambar Styraciflua* L., *Fraxinus Americana* L., *Sambucus Canadensis* L., *Cephalanthus occidentalis* L., *Rosa lucida* Ehrh. with *Parthenocissus quinquefolia* (L.) Planch. (*Ampelopsis quinquefolia* Michx.) and *Rubus nigrobaccus* Bailey. The herbaceous associations of the woody plants mentioned are in this rich alluvial soil *Thalictrum polygamum* Muhl., *Heracleum lanatum* Michx., *Agrimonia parviflora* Soland., *Allium vineale* L., *Ambrosia trifida* L., *Impatiens biflora* Walt. (*I. fulva* Nutt). In mud near the bank, associations of the rose mallow, *Hibiscus Moscheutos* L., occur, with occasional patches of the sensitive fern, *Onoclea sensibilis* L. Along the edges of the stream-banks in the shallow water grow *Clinopodium vulgare* L. (*Calamintha Clinopodium* Benth.), *Jussiaea diffusa* Forsk. (*J. repens* Sw.), *Sagittaria latifolia* Willd. (*S. variabilis* Engelm.), *Cicuta maculata* L., *Ludwigia alternifolia* L., *Stachys palustris* L. and *Asclepias incarnata* L. In the deeper water fringing the shore of the creeks, strips of wild rice, *Zizania aquatica* L. (*Zizania* association) and of *Nymphaea advena* Soland. (*Nuphar* association) are found.

The tidal marshes of the rivers Delaware and Schuylkill are extensive and may be in places one half a mile wide (FIG. 1). Several well-marked zonal areas of marsh vegetation are noticeable in making an ecologic survey. Some of the marshes have been diked. Others at high tide are flooded with water, and yet the ecologist can distinguish relative depths of water by the character of the vegetation alone (FIGS. 2, 3, 4). If one begins with the open channels of the creeks and ditches that intersect the marshes, the following zonal areas can be distinguished. In the deeper water along the channel, the reed-grass, *Zizania aquatica* (*Zizania* association) forms the outer fringe of vegetation (FIGS. 2, 3, 4, *A*, *AA*) and where it does not occur *Nymphaea advena* replaces it and forms a pure growth (*Nuphar* association) (FIGS. 2, 3, *E*). In July two colors of reed-grass are noticeable: a dark green mature form in deep water (FIGS. 2, 3, 4, *A*) and a light green immature growth of reed-grass inside of the dark green area (FIGS. 3, 4, *AA*). In the shallower water behind the reed-grass and spatterdock several associations of plants are seen. One area (FIG. 2, *J*) is characterized by the commingling of *Sagittaria latifolia*, *Impatiens biflora*, *Ambrosia trifida*, *Nymphaea advena*, with an occasional association of *Hibiscus Moscheutos* (FIG. 2, *H*) and on the drier area *Sambucus Canadensis* (FIG. 2, *KKK*, *KKKK*), *Cephalanthus occidentalis*, *Parthenocissus quinquefolia*, *Rubus nigrobaccus* and a few willows, *Salix alba* (FIGS. 2, 4, *W*). In other areas (FIG. 2, *O*) *Impatiens biflora*, *Rudbeckia laciniata* and *Sagittaria latifolia* occur, and on drier soil (FIG. 2, *M*) *Thalictrum polygamum* and *Heracleum lanatum*. As shown in FIG. 3, *D*, *Typha latifolia* forms a pure association (*Typha* association) surrounded by

Ambrosia trifida and *Sagittaria latifolia* (FIG. 3, *BBB*), in other areas this forms pure associations (FIGS. 3, 4, *B*) and in still other situations it is mixed with *Cicuta maculata* (*Sagittaria-Cicuta* association) (FIG. 3, *F*). *Cephalanthus occidentalis* always occurs in the drier soil of the tidal marshes and in a number of places

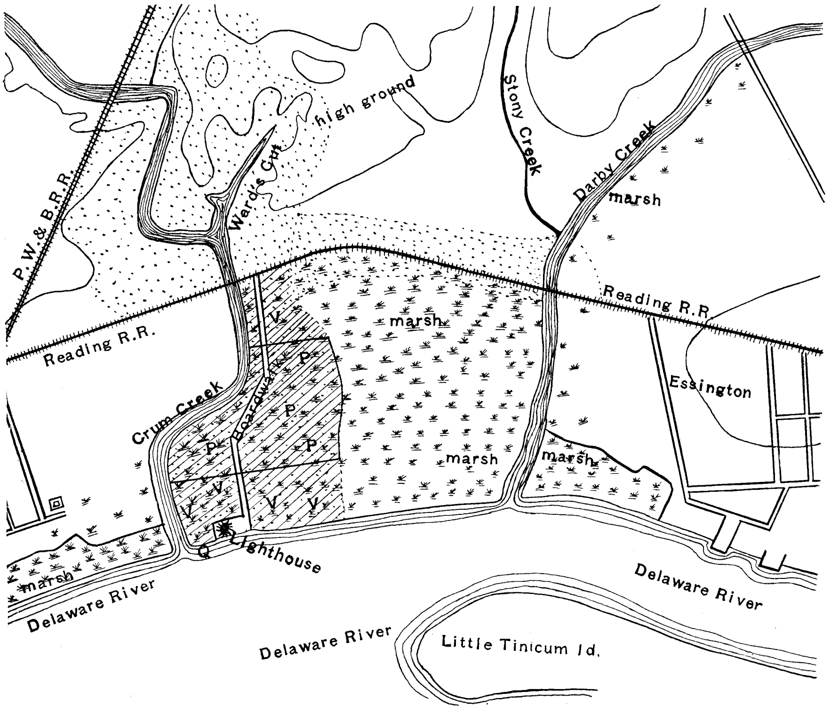

FIG. 1. Map showing position of tidal-marsh region surveyed. The area traversed is represented as the dotted portion of the map. The area surveyed ecologically is represented by the portion designated by the oblique lines (*V*). The area of the marsh (*P*) enlarged in figures 2, 3, and 4 is inclosed by the heavy lines. The position of the *Scirpus* association is shown at *Q*. The open river marsh (not diked) is indicated, as also the location of the high ground.

with it grow *Cornus Amomum* Mill. (*Cornus sericea* L.), *Sambucus Canadensis* L. (FIG. 2, *S*), *Stachys palustris* L. and *Convolvulus sepium* L. (*Calystegia Sepium* L.) (FIG. 3, *K*). Alluvial islands occur in the channels of the streams. These are at first covered by the spatterdock, and as the soil becomes drier through the building action of these plants, the spatterdock is replaced by other plants, until the island becomes dry enough to support tree vegetation. The disposition of the several associations of plants can be studied best by reference to the graphic representations of plant distribution accompanying the text. The marshes have been drained in many cases sufficiently to raise marsh-grass for hay. The ditches of such converted marshes afford many interesting plants, such as

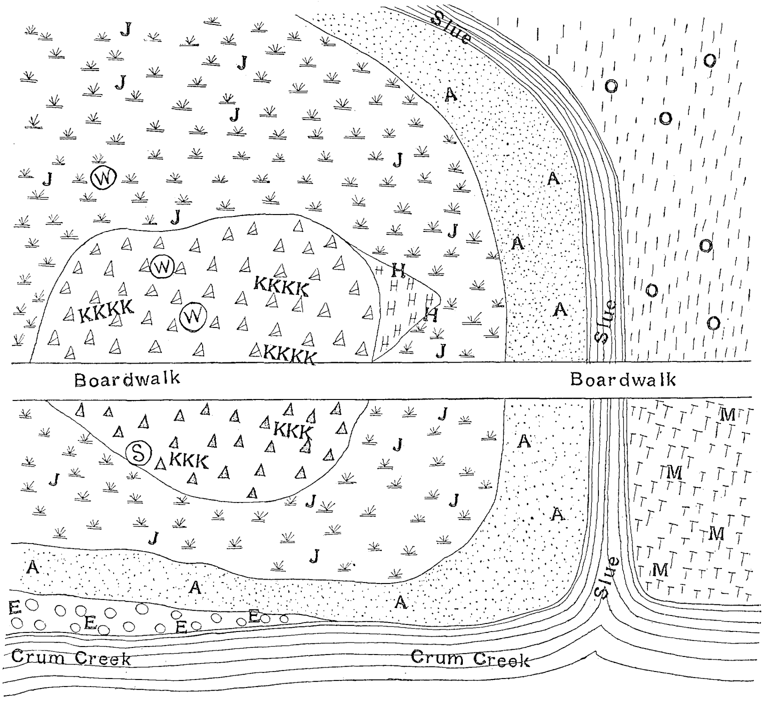

FIG. 2. Portion of tidal-marsh-plant formation shown in Fig. 1. *A*, area of *Zizania aquatica* L.; *E*, *Nuphar* association; *J*, *Sagittaria latifolia* Willd. and *Ambrosia trifida* L.; *KKK*, *Sambucus Canadensis* L., *Cephalanthus occidentalis* L. and *Rubus nigrobaccus* Bailey; *KKKK*, area occupied by willows, *W*, and *Sambucus Canadensis* L.; *H*, *Hibiscus Moscheutos* L.; *O*, *Impatiens biflora* Walt., *Rudbeckia latifolia* Willd. and *Sagittaria latifolia* Willd.; *M*, *Thalictrum polygamum Muhl.* and *Heracleum lanatum* Michx.

Spirodela polyrhiza (L.) Schleid., *Lemna minor* L., *Wolffia Brasiliensis* Wedd., *W. Columbiana* Karst. (*Lemna* association), *Pontederia cordata* L. (FIG. 4, *C*), *Asclepias incarnata* L., *Typha latifolia* L., *Sagittaria subulata* (L.) Buchenau (*S. pusilla* Nutt.), *S. rigida* Pursh (*S. heterophylla* Pursh), *S. latifolia* Willd., *Zizania aquatica*

L. and *Hibiscus Moscheutos* L. Outside of these associations and growing in the deeper water along the banks of the Delaware River is an association of *Scirpus lacustris* L. (*Scirpus* association) (FIG. 1, *Q*, near lighthouse).

SWAMP-PLANT FORMATION. — The swamps of the region under consideration are of three kinds, as determined by their origin: (1) Swamps that owe their origin to a stream flowing over a low, flat area of country; (2) swamps due to underground springs; (3) swamps due to the collection of the drainage water of an area into a natural basin-shaped depression. True sphagnum bogs are not represented in southeastern Pennsylvania. This

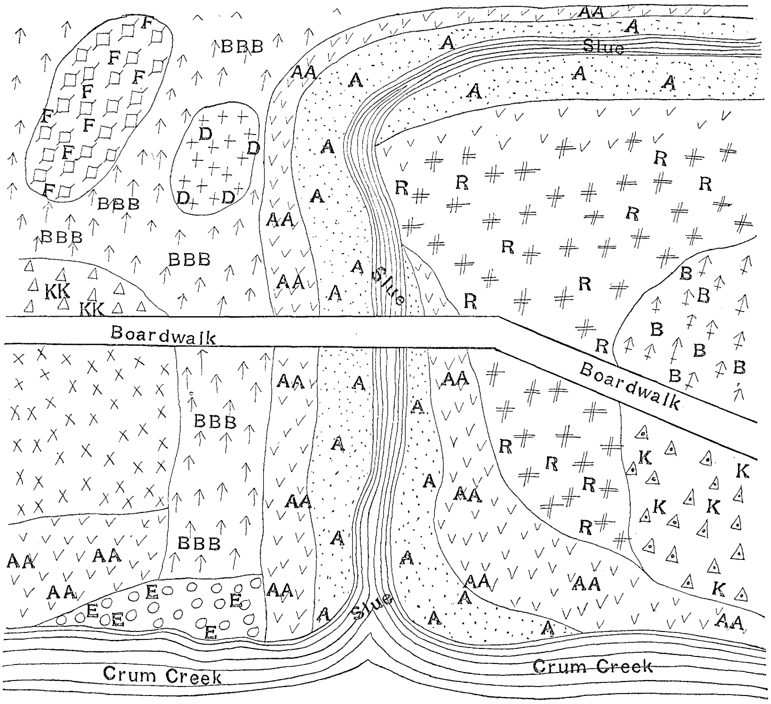

FIG. 3. Portion of the tidal-marsh-plant formation shown in Fig. 1. *A*, dark green *Zizania aquatica* L.; *AA*, light green *Zizania aquatica* L.; *E*, *Nuphar* association; *B*, *Sagittaria* association; *BBB*, *Sagittaria latifolia* Willd. and *Ambrosia trifida* L.; *D*, *Typha* association; *F*, *Cicuta-Sagittaria* association; *K*, *Convolvulus Sepium* L., *Sambucus Canadensis* L., *Cornus amomum* Mill. and *Cephalanthus occidentalis* L.; *R*, *Sagittaria latifolia* Willd. and *Rudbeckia laciniata* L.

does not exclude sphagnum mosses from the category of swamp plants, but bogs which owe their character to them are absent, and peaty deposits such as one finds associated with the sphagnum are entirely wanting. The swamp plants characteristic of the region may be enumerated in the following list: *Carex*, *Scirpus* and *Cyperus*, several species, *Onoclea sensibilis* L., *Osmunda regalis* L., *O. Claytoniana* L., *O. cinnamomea* L., *Spathyema foetida* (L.) Raf., *Acorus Calamus* L., *Typha latifolia* L., *T. angustifolia* L., *Iris versicolor* L., *Carex squarrosa* L., *Veratrum viride* Ait., *Thalictrum polygamum* Muhl., *Impatiens biflora* Walt., *I.*

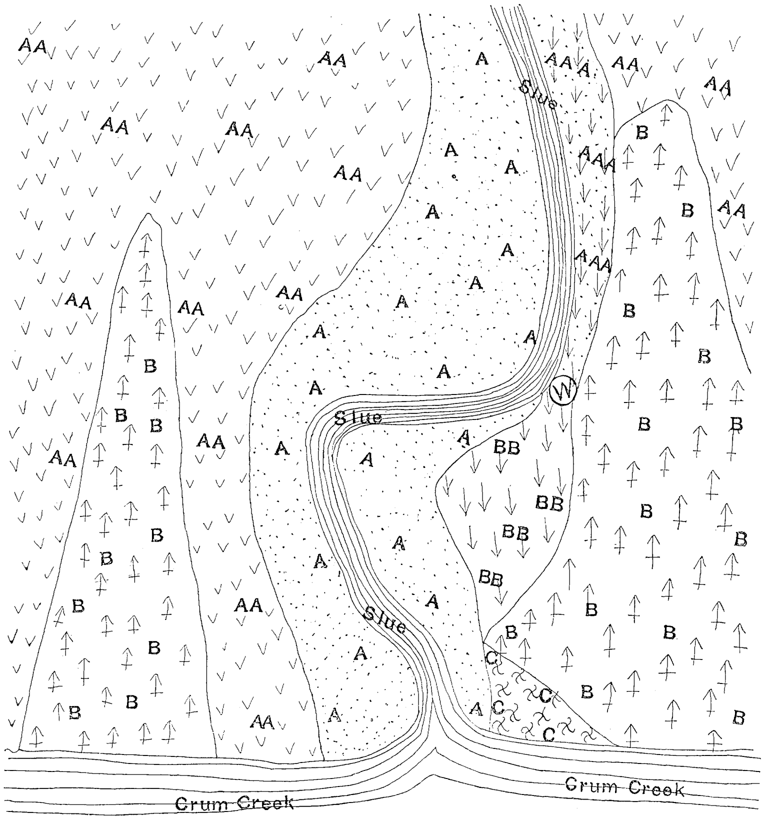

FIG. 4. Portion of tidal-marsh-plant formation shown in Fig. 1. *A*, dark green *Zizania aquatica* L.; *AA*, light green *Zizania aquatica* L.; *B*, *Sagittaria latifolia* Willd.; *BB*, *Sagittaria latifolia* Willd., a form with narrower leaves; *AAA*, dark and light green *Zizania aquatica* L., mixed; *W*, *Salix alba* L.; *C*, *Pontederia cordata* L.

aurea Muhl., *Cardamine bulbosa* (Schreb.) B. S. P., *Drosera rotundifolia* L., *D. intermedia* Hayne, *Sarracenia purpurea* L., *Myosotis palustris* Withering, *Mimulus ringens* L., *Cicuta maculata* L., *Heracleum lanatum* Michx., *Lobelia syphilitica* L., *L. cardinalis* L., *Bidens laevis* (L.) B. S. P., *B. bipinnata* L., *B. frondosa* L., *Rudbeckia laciniata* L., *Eupatorium purpureum* L., *Heliopsis helianthoides* (L.) B. S. P., *Stachys palustris* L., *Alnus rugosa* (DuRoi) K. Koch, *Benzoin Benzoin* (L.) Coult., *Sambucus Canadensis* L., *Ilex verticillata* (L.) A. Gray.

The plants mentioned in the list fall naturally into several ecologic associations. Thus, we have the *Symplocarpus* association, consisting of *Spathyema foetida, Osmunda regalis, O. Claytoniana, O. cinnamomea, Cardamine bulbosa* and *Onoclea sensibilis.* The *Iris, Typha* and *Acorus* associations are clearly demarcated. *Heracleum lanatum* forms in swampy places a pure growth, as do also *Veratrum viride* and *Eupatorium purpureum* (*Heracleum, Veratrum, Eupatorium* associations). *Heliopsis helianthoides, Rudbeckia laciniata, Commelina Virginica, Polygonum sagittatum, Mentha spicata* and *Vernonia Noveboracensis* are usually together in alluvial bottom lands at the mouths of streams where the soil is wet (*Heliopsis-Rudbeckia* association). In similar situations grow *Solidago rugosa* Mill., *Hydrocotyle umbellata* L., *Carduus lanceolatus* Hoffm. and *Lobelia syphilitica* L.

MIXED-DECIDUOUS-FOREST FORMATION. — Originally the forest covered most of the surface of southeast Pennsylvania. In some places, notably on the Wissahickon creek within the confines of Fairmount Park and in areas on Crum creek, the primeval forest still remains. Mr. J. Howard Lewis, Sr., and his progenitors have preserved inviolate a large tract of timber along Crum creek, while the surrounding country settled by patent in 1681 and 1682 has been cleared of its timber for many years. A study of such preserves shows the character of the original forest. The dominant and secondary forest trees grow on precipitous rocks, on declivitous hillsides, on the plateau surfaces left as a remnant of a former peneplain, on the creek bottoms of the region, where the trees reach their largest size, and on the Delaware river plain down to where the forest formation merges with the river marsh plant formation. All of the areas occupied by the cultivated-plant formations recognized in this paper, as well as the roadside-plant formation, the pasture-field-plant formation, the ruderal-plant formation, part of the barren-plant formations and alluvial-soil-plant formations were covered by the original forest. This fact is mentioned because it illustrates how man has altered the character of the original plant formations. By the removal of the original forest, by the introduction of various cultivated plants and weeds, the long-established balance produced by the competition of the native species is rudely disturbed and exotic species come into conflict with the resident species and even the character of the undisturbed formations is altered by the injection of new species into them. However, enough of the virgin forest remains to permit a phyto-geographic survey. The original forest was a mesophytic one. It probably passed through various vicissitudes dependent upon the topographic changes, so that the xerophytic forest of the hillside was gradually replaced by a mesophytic forest. The tendency has been in the entire region to the culmination of the forest in the mesophytic type. The forest, of great original density, may be looked upon as the northeastern extension of the forest found developed in its highest character in the region drained by the Tennessee river and its tributaries and by streams arising in the southern Allegheny mountains and flowing eastward into the Atlantic. Arbitrarily, a line drawn from a point where the Ohio joins the Mississippi river, east to the Cumberland mountains and thence along the Allegheny mountains to the west branch of the Susquehanna river in Pennsylvania, then to the Blue Ridge and along it to the Schuylkill river, following the hills on the south side of the Great Valley to the Delaware river, represents the northern limit during glacial times of the forest which during the Miocene period extend north into the Arctic regions.

The northeastern extension of the forest of glacial times was much poorer in species than the mixed deciduous forest farther south. This was probably due to the killing of the less hardy species by the glacial cold. Only those species remained in the area mentioned that were hardy. These hardy species, therefore, represent the main constituent species of the present-day forest with the possible introduction of a few additional species that migrated north from the denser forest that clothed the valleys and slopes of the southern Allegheny mountains.

The dominant trees of the forest that covered and still covers in patches southeastern Pennsylvania is composed of the following species: Tulip-poplar, *Liriodendron Tulipifera* L.; chestnut, *Castanea dentata* (Marsh.) Borkh. (*Castanea sativa Americana* Gray); black walnut, *Juglans nigra* L.; red oak, *Quercus rubra* L.; white oak, *Q. alba* L.; scarlet oak, *Q. coccinea* Wang.; chestnut oak, *Q. Prinos* L.; Spanish oak, *Q. digitata* (Marsh.) Sudw. (*Q. falcata* Michx.); beech, *Fagus Americana* Sweet (*F. ferruginea* Ait.); *Hicoria ovata* (Mill.) Britton (*Carya alba* Nutt.); hackberry, *Celtis occidentalis* L.; butternut, *Juglans cinerea* L.; sweet gum, *Liquidambar Styraciflua* L.; persimmon, *Diospyros Virginiana* L.; white elm, *Ulmus Americana* L.; white ash, *Fraxinus Americana* L.; wild red cherry, *Prunus Pennsylvanica* L.f.; pignut, *Hicoria glabra* (Mill.) Britton (*Carya porcina* Nutt.); silver maple, *Acer saccharinum* L. (*Acer dasycarpum* Ehrh.); sugar maple, *Acer saccharum* Marsh. (*Acer saccharinum* Wang.); red maple, *Acer rubrum* L., buttonwood, *Platanus occidentalis* L.; small-fruited hickory, *Hicoria microcarpa* (Nutt.) Britton (*Carya microcarpa* Nutt.); and ironwood, *Ostrya Virginiana* (Mill.) Willd. These trees are found on a great variety of soils, but reach their greatest size on the dry alluvial soils of the creek and river bottoms. Thus the black walnut, tulip-poplar, white elm, buttonwood, red maple and silver maple reach their best development on such soils. The white oak, white ash, chestnut, etc., seem to grow equally well in the drier upland soils. The red cedar, *Juniperus Virginiana* L., on the other hand, seems to be confined to barren places and to rocky outcrops, while the trees that grow along the banks of the streams within the region comprise the red maple, *Acer rubrum* L.; the hornbeam, *Carpinus Caroliniana* Walt.; swamp oak, *Quercus palustris* DuRoi; buttonwood, *Platanus occidentalis* L.; box-elder, *Acer Negundo* L. (*Negundo aceroides* Moench); beech, *Fagus Americana* Sweet; *Sassafras Sassafras* (L.) Karst. (S. *officinale* Nees), and several birches and willows.

These trees form a dense canopy, and shade the forest floor, so that the secondary species, shrubs, sapling trees and herbs, must be tolerant of such dense shade. The dominant trees reached great size in the primeval forest, for some are left which attest this. Thus are found white oaks six to eight feet in diameter, buttonwood trees six feet across, white pine five feet in diameter, beeches four feet, black walnut trees four to five feet, tulip-poplars six feet, sassafras trees two feet and a half. The secondary species tolerant of the shade are the dogwood, *Cornus florida* L., red mulberry, *Morus rubra* L., service berry, *Amelanchier Canadensis* (L.) Medic, bladdernut, *Staphylea trifolia* L., Judas-tree, *Cercis Canadensis* L., hazel, *Corylus Americana* Walt., witch hazel, *Hamamelis Virginiana* L., and striped maple, *Acer Pennsylvanicum* L., while as shrubs occur smooth alder, *Alnus rugosa* (Du Roi) K. Koch, spice-bush, *Benzoin Benzoin* (L.) Coulter, dockmackie, *Viburnum acerifolium* L., arrowwood, *Viburnum dentatum* L., stagbush, *Viburnum prunifolium* L., strawberry bush, *Euonymus Americanus* L., wahoo, *Euonymus atropurpureus* Jacq., and pinxter flower, *Azalea nudiflora L.* (*Rhododendron nudiflorum* Torr.); *Sambucus Canadensis*, the elder, also occurs in the region and at present is found usually in open places with alluvial soil forming thickets of some denseness. The laurel, *Kalmia latifolia* L., high-bush huckleberry, *Gaylussacia resinosa* (Ait.) Torr. & Gray and deerberry, *Polycodium stamineum* (L.) Greene (*Vaccinium stamineum* L.), are found in the drier forest soils throughout the region. The lianes which grow upon the dominant and secondary forest trees are several grape-vines, *Vitis cordifolia* Michx., *V. labrusca* L., *V. aestivalis* Michx., *V. vulpina* L. (*V. riparia* Michx.), Virginia creeper, *Parthenocissus quinquefolia* (L.) Planch., poison ivy, *Rhus radicans* L., and several species of the genus *Smilax*. The climbing bittersweet, *Celastrus scandens* L., moonseed, *Menispermum Canadense* L., *Sicyos angulatus* L., wild-yam, *Dioscorea villosa* L., and wild balsam apple, *Micrampelis lobata* (Michx.) Greene (*Echinocystis lobata* Torr. & Gray) are climbing plants found along the courses of streams.

A peculiar type of this mixed deciduous forest is found on the serpentine rock formations of the region under consideration. The botanist can identify the serpentine areas, by the vegetation alone, for the species which are character-plants, although occurring elsewhere in the region, are here grouped together in such a manner and in such number, as to sharply delimit these areas from the surrounding country. The dominant trees on the serpentine barrens are *Quercus alba* L., *Q. stellata* Wang., *Quercus Marylandica* Muench, *Acer rubrum L.*, *Liriodendron Tulipifera* L., *Nyssa sylvatica* Marsh., *Juniperus Virginiana* L., *Castanea dentata* (Marsh.) Borkh., *Fagus Americana* Sweet, *Quercus rubra* L. and *Prunus serotina* Ehrh., while associated with these trees are *Sassafras Sassafras* (L.) Karst. *Rhus glabra* L., *Kalmia latifolia* L., *Salix tristis* Ait., *Cornus florida* L., *Viburnum dentatum* L., *Polycodium stamineum* (L.) Greene, *Gaylussacia resinosa* (Ait.) Torr. & Gray, *Viburnum acerifolium* L. and *Benzoin Benzoin* (L.) Coult. The lianes are *Vitis aestivalis* Michx., *Parthenocissus quinquefolia* (L.) Planch., *Rhus radicans* L., *Smilax rotundifolia* L. and *S. glauca* Walt.

The herbaceous plants of the forest floor are found in pure association, or they occur sparingly distributed along with other herbs that form together a mixed vegetation. The habitats of the different herbaceous associations are controlled by photic and edaphic conditions. Thus in the deep shade of the dominant trees, the botanist finds the following plants forming pure associations and each association may be distinguished by the generic name of the plant :

April. — *Asarum Canadense* L., *Bicuculla cucullaria* (L.) Millsp. (*Dicentra cucullaria* DC.), *Erythronium Americanum* Ker, *Claytonia Virginica* L., *Pedicularis Canadensis* L., *Epigaea repens* Lam., *Thalictrum dioicum* L.

May. — *Cubelium concolor* (Forst.) Raf. (*Solea concolor* Ging.), *Podophyllum peltatum* L., *Triosteum perfoliatum* L., *Tradescantia Virginiana* L., *Mertensia Virginica* (L.) DC., *Caulophyllum thalictroides* (L.) Michx., *Hydrophyllum Virginicum* L.

July. — *Gaultheria procumbens* L.

The following ferns are also found in pure association in the forest : *Adiantum pedatum* L., *Dryopteris spinulosa* (Retz) Kuntze, (*Aspidium spinulosum* Swartz), *Dryopteris marginalis* (L.) A. Gray (*Aspidium marginale* Swartz), *Dryopteris acrostichoides* (Michx.) Kuntze (*Aspidium acrostichoides* Sw.) and *Phegopteris Phegopteris* (L.) Underw. (*P. polypodioides* Fée).

Along the woodland streams, growing in the damp loamy soil of such situations and controlled by the amount of soil-moisture present are a number of associations characterized by a single plant, as follows:

April. — *Floerkea proserpinacoides* Willd.

May. — *Polemonium reptans* L., *Valerianella chenopodifolia* (Pursh.) D.C., *Ornithogalum umbellatum* L., *Heracleum lanatum* Michx.

June. — *Lysimachia nummularia* L.

July. — *Impatiens biflora* Walt., *I. aurea* Muhl., *Thalictrum polygamum* Muhl., *Adicea pumila* (L.) Raf. (*Pilea pumila* Gray).

August. — *Leptamnium Virginianum* (L.) Raf. (*Epiphegus Virginiana* Bart.), *Lobelia cardinalis* L., *Commelina nudiflora* L. *C. Virginica* L.

September. — *Eupatorium purpureum* L.

The rocky outcrops in the woods consisting either of ledges or of angular boulders formed by frost action are covered by several well-characterized associations formed by pure growths of the following species:

Camptosorus rhizophyllus (L.) Link, *Polypodium vulgare* L.

April. — *Saxifraga Virginiensis* Michx., *Aquilegia Canadensis* L.

May. — *Heuchera Americana* L.

The herbaceous flora of the woods found on the serpentine areas of southeastern Pennsylvania has been discussed in a paper by the writer entitled "The flora of the serpentine barrens of southeast Pennsylvania." * As the facts have been presented there in some detail, it is hardly necessary to repeat the observations so recently published. The student is referred to that paper for an account of the distribution of the serpentine plants.

Besides these pure associations of plants found in the woods of southeast Pennsylvania occur a large number of species, rich in number of individuals, but scattered on the forest floor, separated from each other by spaces filled up with other characteristic woodland species, likewise isolated. These plants, therefore, form a mixed vegetation which covers the ground except where the pure associations of single species occur and give character to the herbaceous flora of such woodland areas. The following species may be included in this category. They are arranged, because of what follows, according to the months in which they appear in flower.

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*Science, II. 18: 339–343. 11 S 1903.

Botrychium Virginianum (L.) Swartz, *Asplenium Filixfoemina* (L.) Bernh.

April. — *Dentaria laciniata* Muhl., *Viola palmata* L., *Ranunculus abortivus* L., *Geranium maculatum* L., *Arisaema triphyllum* (L.) Torr., *Erigeron pulchellus* Michx. (*E. bellidifolium* Muhl.), *Sanguinaria Canadensis* L., *Hepatica Hepatica* (L.) Karst. (*H. triloba* Chaix.), *Syndesmon thalictroides* (L.) Morong (*Anemonella thalictroides* Spach), *Panax trifolia* L. (*Aralia trifolia* Decsne & Planch.), *Mitella diphylla* L., *Viola Labradorica* Schrank (*V. canina Muhlenbergii* Gray), *V. blanda* Willd., *V. villosa* Walt., *V. pedata* L., *Carex Pennsylvanica* Lam., *Barbarea Barbarea* (L.) MacM. (*B. vulgaris* R. Br., *Ranunculus fascicularis* Muhl.

May. — *Washingtonia longistylis* (Torr.) Britton (*Osmorrhiza longistylis* DC.), *Vagnera racemosa* (L.) Morong (*Smilacina racemosa* Desf.), *Viola pubescens* Ait., *Thalesia uniflora* (L.) Britton (*Aphyllon uniflorum* Gray), *Oxalis stricta* L. (*O. corniculata stricta* Sav.), *Uvularia sessilifolia* L. (*Oakesia sessilifolia* Watson), *Trientalis Americana* (Pers.) Pursh, *Salomonia commutata* (R. & S.) Britton (*Polygonatum giganteum* Dietr.), *Medeola Virginica* L., *Galeorchis spectabilis* (L.) Rydb. (*Orchis spectabilis* L.), *Hypoxis hirsuta* (L.) Coville (*H. erecta* L.), *Tiarella cordifolia* L., *Hydrastis Canadensis* L., *Thaspium trifoliatum aureum* (Nutt.) Britton (*T. aureum* Nutt.), *Aralia nudicaulis* L., *Cypripedium acaule* Ait., *Allium tricoccum* Ait., *Arisaema Dracontium* (L.) Schott, *Hieracium venosum* L., *Oxalis violacea* L., *Uvularia perfoliata* L., *Smilax herbacea* L., *Geranium maculatum* L., *Juncoides campestre* (L.) Kuntze (*Luzula campestris* DC.), *Ficaria Ficaria* (L.) Karst. (*Ranunculus Ficaria* L.).

June. — *Pyrola rotundifolia* L., *Galium triflorum* Michx., *Cynoglossum Virginicum* L., *Corallorhiza odontorhiza* Nutt., *Uvularia grandiflora* Smith, *Scutellaria serrata* Andrews, *Leptorchis liliifolia* (L.) Kuntze (*Liparis liliifolia* Richard), *Cypripedium hirsutum* Mill. (*C. pubescens* Willd.), *Cypripedium parviflorum* Salisb., *Hieracium Gronovii* L., *H. scabrum* Michx., *Chimaphila maculata* (L.) Pursh, *Galium aparine* L.

July. — *Cimicifuga racemosa* (L.) Nutt., *Urticastrum divarica-*

tum (L.) Kuntze (*Laportea Canadensis* Gaud.), *Chelone glabra* L., *Panicum dichotomum* L., *Lilium Canadense* L., *Monotropa uniflora* L., *Prunella vulgaris* L., *Silene stellata* Ait., *Phryma leptostachya* L.

August. — *Lobelia syphilitica* L., *Solidago bicolor* L., *Aster macrophyllus* L., *Panicum microcarpon* Muhl.

September. — *Aster laevis* L., *Solidago caesia* L., *Collinsonia Canadensis* L.

All of these species are not found in a single wooded area. They are distributed in different combinations in southeastern Pennsylvania. Thus such local plants as *Cypripedium parviflorum*, *C. hirsutum*, *Camptosorus rhizophyllus*, *Galeorchis spectabilis*, *Hydrastis Canadensis* and *Leptorchis liliifolia* occur only in a few places in the region, but they are mentioned because they are plants which grow best in the deep shade formed by the crown of the dominant forest trees. The vegetal covering of the forest floor also differs with the season of the year, so that the spring flora is distinct from that of the summer flora, and the summer flora is distinct from the autumn flora. In the lists above this succession of floras is displayed, as far as the phenologic data at command will permit. The woodland species are most numerous in the spring, because the conditions are most favorable for their growth. Such plants as the bloodroot, wild ginger, May apple, windflower and lady's slipper abound. The summer flora of the woods is poorer in the number of species. Such plants as touch-me-not, cardinal lobelia, boneset, all-heal, etc., are found with a number of funguses, such as *Russula*, etc. The autumn flora of the forest consists of asters, golden-rods, mints, and a large number of toadstools and mushrooms, which feed saprophytically upon the humus of the soil composed of leaf-mold and rotted wood. The phenologic distribution of the woodland species is, therefore, quite as marked as their geographic habitat and controls associations of species in a most intimate manner. The seasonal sequence of species is one of the controlling factors in the struggle for existence. With the exception of the rivalry of the root and underground stem systems for ground-space, the spring plant may be said not to come into competition with the summer- and- autumn flowering species and conversely.

The mutual aid which plants show is quite as important in the grouping of associations, as the struggle for light and soil room. The beech-drop for example is dependent on the beech, and hence it is only found where the beech is an element of the forest. The Indian-pipe occurs only in woods where there is abundant humus, as also the majority of ericaceous plants provided with mycorhiza. Certain funguses are dependent upon the material formed by the decay of certain other plants and they, therefore, abound only where this material is found. The fungous flora of a particular forest area comes and goes in an inexplicable manner. One season there will be an abundance of a particular species and during another season that species cannot be found, but will be replaced by some other form. The character of the rainfall, whether light, heavy or frequent is a determining factor in the appearance of plants. With a heavy downpour most of the water which has fallen runs off the surface and does very little good. On the other hand, gentle rains which come frequently soften the ground, and thus furnish some water to the lower strata, or at least preserve the supply which is already there. The writer believes that there is a delicate balance of some kind established between fungi and the climatic and edaphic conditions of any neighborhood. It is only when the climatic and edaphic conditions are suitable that the fungus species again appears.* The conditions, therefore, which control the character of the vegetal covering of a mesophytic forest are most complex and intricate.

HEMLOCK FORMATION. — This formation occurs on the sloping hillsides and precipitous banks of streams and is developed notably on Wissahickon and Crum creeks. It is found generally along the Wissahickon creek and at the ox-bow of Crum creek below the Springfield water works on the north and west banks of the stream at this point. The forest of hemlocks consists in a few places of a pure growth without the admixture of any other tree species, but usually associated with the hemlock, *Tsuga Canadensis* (L.) Carr. the botanist finds the beech, *Fagus Americana* and red maple, *Acer rubrum*. These trees are tolerant of the dense shade of the hemlocks. Where the forest floor has not been disturbed, sapling hemlocks, beeches and red maples are present ready to replace the dominant trees when they have succumbed to the wind. On the floor of the forest in places *Lycopodium lucidulum* Michx. forms an association (*Lycopodium* association). The laurel, *Kalmia latifolia* L., occurs in the drier soils and forms a thicket (*Kalmia* association). *Mitchella repens* L. carpets the ground (*Mitchella* association) and *Viola rotundifolia* Michx. is a character-plant with which grows *Peramium pubescens* (Willd.) MacM., *Cinna latifolia* (Trev.) Griseb., *Hieracium paniculatum* L., and in late summer *Aster divaricatus* L. In many places, the hemlock, *Tsuga Canadensis*, forms an element in the mixed-deciduous-forest formation. When such is the case, it is found in isolated patches usually of a few trees near the water-courses on steep hillsides. It forms then an association (*Tsuga* association) and with *Lycopodium lucidulum* are found three other species, viz., *Lycopodium annotinum* L., *L. clavatum* L., and *L. obscurum* L. (*L. dendroideum* Michx.), which grow near the hemlocks. Two alternative hypotheses may be adduced for this. Either an original hemlock forest has been replaced by a deciduous one, or occasional hemlock trees have been under certain edaphic conditions developed amidst the component species of the deciduous forest.

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* *Cf.* Whitney, M. & Cameron, F. K. The chemistry of the soil as related to crop production. U. S. Dep. Agr. Bureau Soils Bull. 22 : 47–55. 1903.

SERPENTINE-BARREN TREELESS FORMATION.—The details concerning this formation will not be given here, as an account has been given elsewhere of the character of the vegetation of the serpentine barrens.* The herbs found upon the broken-down serpentine rock are *Phlox subulata* L. (*Phlox* association), *Trifolium aureum* L. (*T. agrarium* L.), *Pteridium aquilinum* (L.) Karst. (*Pteris aquilina* L.), *Verbascum Blattaria* L., *Panicum latifolium* L., *Potentilla Canadensis* L., *Cerastium oblongifolium* Torr. (*Cerastium* association), *Senecio Balsamitae* Muhl. (*Senecio aureus Balsamitae* Torr. & Gray), *Castilleia coccinea* (L.) Spreng., *Arenaria stricta* Michx., *Talinum teretifolium* Pursh, *Ixophorus glaucus* (L.) Nash (*Setaria glauca* Beauv.), *Aster ericoides depauperatus* Porter, *Polygonum tenue* Michx., *Lespedeza Virginica* (L.) Britton, *Andropogon scoparius* Michx., *Solidaga puberula* Nutt., *Eupatorium aromaticum* L., *Panicum dichotomum* L., *Koellia flexuosa* (Walt.) MacM.

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* Harshberger, J. W. The flora of the serpentine barrens of southeast Pennsylvania. Science, II. 18: 339–343. 11 S 1903.

(*Pycnanthemum linifolium* Pursh) and in wet places *Cyperus inflexus* Muhl. and *Fimbristylis laxa* Vahl.

MEADOW-PASTURE-FIELD-PLANT FORMATION.* — From early historic accounts of the region, the original forest was interspersed with open glades and natural meadows where for some edaphic reason the trees did not grow. These areas (such as we have left in the "Indian clearing" near Lima, Delaware County, and in the Playwicky clearing in Bucks County) were settled upon first, and with the exception of the areas above mentioned we have no natural openings that have not been altered by the hand of man. The botanist, therefore, has no data upon which to base a statement of the plant covering of such open, treeless areas.

Several kinds of fields may be distinguished. A classification of the plants according to the character of the inclosed areas might be made, but it would be too minute for a general phyto-geographic survey, such as this paper is intended to be. The uncultivated fields of southeastern Pennsylvania may be classified as follows:

1. Fields formed by clearing of the original timber.
2. Wet fields that may be called meadows, usually level and situated in low ground.
3. Barren fields characterized by the shallowness or poor character of the soil.
4. Dry fields that are fertile, but lack abundant water, the rain draining off after it falls. These fields are situated usually on hillsides.
5. Fields with rich soil that have been fallow, and that are used as pastures.
6. Abandoned fields in which weeds have been allowed to grow rampant and in which trees are beginning to appear.

Fields of the first class, formed by the clearing away of the original timber, are usually at once cultivated by plowing and sowing between the stumps; occasionally, however, they are left uncultivated and they become veritable weed patches. Most of the herbaceous weeds, mentioned as growing in cultivated areas, appear and occupy the ground. Some of the original woodland species, such as *Podophyllum peltatum* L., etc., remain as a characteristic plant growth. If permitted to relapse again to natural conditions, fields of the first class become fields of the sixth class in three or four years time.

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* For a list of plants peculiar to this formation on Darby Creek, the writer is under obligations to Miss Lydia P. Borden, of Manoa, Delaware County, Pa.

Meadow-land (2) may be defined as that which has been reclaimed from a too wet condition by ditch or tile drainage. Compared with other field-areas meadows are relatively better supplied with ground water. Meadow-land merges into a swamp on the one hand or a cultivated field on the other. Plants growing in meadow-land are, therefore, not subjected to the vicissitudes of cultivation, but they are trodden down and browsed upon by cattle turned into such areas. Associations of species are not always clearly marked in meadows and no attempt is made to group the plants together naturally. A list of meadow plants is given by way of calling attention to the plants of the region which grow in such localities.

Anthoxanthum odoratum L., *Dactylis glomerata* L., *Lolium perenne* L., *Andropogon Virginicus* L., *Phleum pratense* L., *Alopecurus geniculatus* L., *Agrostis alba* L., *Poa annua* L., *P. compressa* L., *P. pratensis* L., *P. trivialis* L., *Cyperus strigosus* L., *Carex* (various species), *Juncus* (several species), *Scirpus* (several species), *Trifolium pratense* L., *T. repens* L., *T. agrarium* L., *T. procumbens* L., *T. hybridum* L., *Melilotus alba* Desv., *Muscari botryoides* (L.) Mill., *Daucus Carota* L., *Hedeoma pulegioides* Pers., *Hypericum perforatum* L., *Polygonum Pennsylvanicum* L., *P. scandens* L. (*P. dumetorum scandens* Gray), *Eupatorium perfoliatum* L., *E. ageratoides* L., *E. purpureum* L., *Prunella vulgaris* L., *Chrysanthemum Leucanthemum* L., *Achillea Millefolium* L., *Lappula Virginiana* (L.) Greene (*Echinospermum Virginicum* Lehm.), *Strophostyles angulosa* Ell., *Glechoma hederacea* L. (*Nepeta Glechoma* Benth.), *Nepeta Cataria* L., *Potentilla Canadensis* L., *Salvia lyrata* L., *Specularia perfoliata* (L.) A. DC., *Ranunculus bulbosus* L., *R. abortivus* L., *R. septentrionalis* Poir., *Bursa Bursa-pastoris* (L.) Britton (*Capsella Bursa-pastoris* Moench), *Barbarea Barbarea* (L.) MacM. (*B. vulgaris* R. Br.), *Taraxacum Taraxacum* (L.) Karst. (*T. officinale* Weber), *Alsine media* L.

Growing in the wetter portions of the meadows near the streams that frequently run through such areas, the botanist finds

Spathyema foetida, Heracleum lanatum, Rudbeckia laciniata, Impatiens biflora, I. aurea, Lobelia syphilitica, L. cardinalis, Bidens laevis, B. bipinnata, B. frondosa, Cicuta maculata, Thalictrum polygamum, Lilium superbum, Monarda fistulosa, Sium cicutaefolium, Lobelia Nuttallii, Mimulus ringens, Myosotis palustris, Iris versicolor, Stellaria longifolia, Mentha spicata, Lysimachia quadrifolia, Veratrum viride and *Scutellaria integrifolia.*

Many of these plants have remained after the removal of the timber and some of them have advanced into the meadows from the adjacent forest. This is especially true of the species enumerated below. They are woodland species that have adapted themselves to growing in the open. *Erythronium Americanum* Ker., *Valerianella chenopodifolia* (Pursh) DC., *Cardamine bulbosa* (Schreb.) B. S. P., *Polemonium reptans* Michx., *Senecio aureus* L., *Ornithogalum umbellatum* L., *Tradescantia Virginiana* L., *Geranium maculatum* L., *Podophyllum peltatum* L., *Steironema ciliatum* (L.) Raf., *Lilium superbum* L., *Monarda fistulosa* L., *Bicuculla cucullaria* (L.) Millsp., *Arisaema triphyllum* (L.) Torr., *Phytolacca decandra* L., *Salomonia commutata* (R. & S.) Britton, *Clematis Virginiana* L. along the fences, *Vagnera racemosa* (L.) Morong, *Hydrophyllum Virginicum* L., *Salvia lyrata* L., *Origanum vulgare* L., *Thaspium trifoliatum aureum* (Nutt.) Britton, *Viola* (several species), *Uvularia perfoliata* L., *Cimicifuga racemosa* (L.) Nutt., *Mentha* (several species), *Commelina nudiflora* L., *Scutellaria integrifolia* L.

The pasture-fields of categories 3, 4, 5 supply a number of plants which are not found in the meadow-land proper. Most of the aforementioned grasses are encountered and also a large number of woodland species, that have been introduced since the timber was removed, as well as the majority of the introduced weeds mentioned above.

The plants listed below usually grow in drier soil than the meadows afford.

Helianthus giganteus L., *Rudbeckia hirta* L., *Vernonia Noveboracensis* Willd., *Solidago serotina* Ait., *S. nemoralis* Ait., *S. rugosa* Mill., *S. caesia* L., *Aster ericoides* L., *A. puniceus* L., *Ambrosia artemisiaefolia* L., *Bidens discoides* (T. & G.) Britton (*Coreopsis discoidea* Torr. & Gray), *Heliopsis helianthoides* (L.) B. S. P. (*Heliopsis laevis* Pers.), *Arctium Lappa* L., *Asclepias Syriaca L.* (*A.*

Cornuti Decaisne), *A. purpurascens* L., *Apocynum androsaemifolium* L., *Clinopodium vulgare*, *Hypericum perforatum* L., *Dianthus prolifera* L., *Onagra biennis* (L.) Scop. (*Oenothera biennis* L.), *Chenopodium album* L., *Cunila origanoides* (L.) Britton (*C. Mariana* L.) *Potentilla Canadensis* L., *Houstonia caerulea* L., *Linaria Linaria* (L.) Karst. (*L. vulgaris* Mill.), *Specularia perfoliata* (L.) A. DC.

The soil of fields, which may be designated as sandy loam, supports a number of additional species.

Parsonsia petiolata (L.) Rusby (*Cuphea viscosissima* Jacq.), *Veronica officinalis* L., *V. serpyllifolia* L., *Antennaria plantaginifolia* Hook, *Potentilla Canadensis* L., *Fragaria Virginica* Mill., *Lepidium Virginicum* L., *Rumex acetosella* L., *Rubus Canadensis* L., *Sisyrynchium anceps* Cav., *Penstemon pubescens* Solander, *Plantago lanceolata* L., *P. Virginica* L., *P. major* L., *Trichostema dichotomum* L., *Lobelia inflata* L. ,*Verbascum Thapsus* L., *V. Blattaria* L., *Abutilon Abutilon* (L.) Rusby (*A. Avicennae* Gaertn.), *Lycopus Virginicus* L., *L. sessilifolius* Gray, *Anaphalis margaritacea* Benth. & Hook., *Nabalus altissima* (L.) Hook. (*Prenanthes altissima* L.), *N. albus* (L.) Hook. (*Prenanthes alba* L.), *Galinsoga parviflora* Cav., *Euphorbia corollata* L., *Leonurus Cardiaca* L., *Convolvulus Sepium* L., *Leptilon Canadense* (L.) Britton (*Erigeron Canadensis* L.), *Agrimonia Eupatoria* L., *Potentilla Norvegica* L., *Matricaria inodora* L., *Trifolium pratense* L., *T. repens* L., *T. agrarium* L , *T. procumbens* L., *Oxalis stricta* L. (*O. corniculata stricta* Sav.), *Malva rotundifolia* L., *Rhus radicans* L. (along fences and stone heaps), *Saponaria officinalis* L., *Lysimachia nummularia* L., *Andropogon scoparius* Michx., *A. Virginicus* L., *Paspalum setaceum* Michx., *Syntherisma sanguinalis* (L.) Nash. (*Panicum sanguinale* L.), *Panicum nitidum* Lam., *P. capillare* L., *Ixophorus glaucus* (L.) Nash (*Setaria glauca* Beauv.), *I. viridis* (L.) Nash (*S. viridis* Beauv.), *Anthoxanthum odoratum* L., *Phleum pratense* L., *Alopecurus geniculatus* L., *Agrostis alba* L., *Holcus lanatus* L., *Avena fatua* L., *Capriola Dactylon* (L.) Kuntze (*Cynodon Dactylon* Pers.), *Eleusine Indica* (L.) Gaertn., *Sieglingia sesleroides* (Michx.) Scribn. (*Triodia cuprea* J. F. Jacq.), *Dactylis glomerata* L., *Poa annua* L., *P. pratensis* L., *P. trivialis* L., *P. compressa* L., *Festuca ovina* L., *Agropyron repens* (L.) Beauv., *Panicum rostratum* Muhl. (*P. anceps* Michx.).

Fields (6) that are abandoned after a long period of cultivation and in which weeds have been permitted to grow rampant and in which trees begin to appear, show some interesting changes in the flora which are not mentioned in connection with fields of the first category. In such fields, trees appear not from the stump, but as chance seedlings, that grow from seeds carried by the winds or animals. The predominant weeds noticed on an old dam site along Crum creek were *Eupatorium purpureum* L., *Aster* (several species), *Solidago* (several species), *Rubus* (several species), *Chelone glabra* L., *Ambrosia trifida* L., *Rudbeckia laciniata* L., etc. These were surrounded by small trees of the following species: *Betula lenta* L., *Liriodendron Tulipifera* L., *Acer rubrum* L., *Ulmus Americana* L. and *Fraxinus Americana* L. All of these trees have winged fruits and without doubt the trees grew from seeds wafted to the open dam site by the wind.

ROADSIDE-PLANT FORMATION. — The flora of a roadside is peculiar. Along the highways we find a miscellaneous assortment of plants, mostly weeds, with an admixture of native plants that are able to compete with foreign introductions and that have adapted themselves to growing under the more trying conditions of the open, shadeless, dust-laden environment. The weeds of the roadsides in southeastern Pennsylvania have been derived from two main sources, viz., Europe, and eastern North America. The European weeds seem to get the upper hand in the struggle for existence for several reasons: (1) Because they have been longer associated with man and his methods of cultivation; (2) because they have adapted themselves during a thousand years, since Europe was a forest wilderness, to living in the open, in fields along roadsides, and in garden patches; (3) because in migrating to a new country they have been removed from their competitors by whom they were held in subjection through the struggle for existence; (4) because in eastern North America they come into competition with native species mostly derived from the forests and that have not had sufficient time to adapt themselves to the changed conditions produced by the destruction of the forests, the cultivation of the soil and growth in open places subjected to the full force of the sunlight.

Western American weeds, seem to have an advantage, because derived from an open prairie country, where, with frequent fires and the roaming of herds of buffaloes and antelopes, they have been subjected to environmental conditions very similar to those which are met with in the more highly cultivated districts of our eastern states.

Plants derived from the native flora can hardly be looked upon as weeds ("plants out of place"). Only a few of our troublesome weeds are native. The native plants have usually persisted in the soil when a road has been constructed, and in many places they are found in greatest abundance along the highways in rich arable land, because they have been left in undisturbed possession of the stretches of land on either side of the roadway, while the same species have been exterminated in the cultivated fields. In other cases native plants have migrated from the woods and natural meadows to the roadside and have implanted themselves there, especially in those districts of our country cut off from the railroad and other lines of cross-country travel. The plants in the following list are arranged according to their source:

Europe. — *Linaria Linaria* (L.) Karst., *Daucus Carota* L., *Phleum pratense* L., *Hypericum perforatum* L., *Rumex crispus* L., *R. obtusifolius* L., *R. Acetosella* L., *Verbascum Thapsus* L., *V. Blattaria* L., *Plantago lanceolata* L., *Allium vineale* L., *Trifolium pratense* L., *T. arvense* L., *Chrysanthemum Leucanthemum* L., *Arctium lappa* L., *Xanthium glabratum* (DC.) Britton (*X. strumarium* L.), *Anthemis Cotula* DC., *A. arvensis* L., *Taraxacum Taraxacum* (L.) Karst., *Cerastium vulgatum* L., *Lactuca scariola* L., *Asparagus officinalis* L., *Saponaria officinalis* L., *Melilotus alba* L., *Mollugo verticillata* L., *Carduus lanceolatus* L., *C. arvensis* (L.) Robs. (*Cnicus arvensis* Hoffm.), *Datura Stramonium* L., *D. Tatula* L., *Syntherisma sanguinalis* (L.) Nash (*Panicum sanguinale* L.), *Chaetochloa glauca* (L.) Scribn. (*Setaria glauca* Beauv.), *Eleusine Indica* (L.) Gaertn., *Polygonum Persicaria* L., *Chenopodium album* L., *C. anthelminthicum* L. (*C. ambrosioides anthelminthicum* Gray), *Atriplex hastata* L., *Amaranthus spinosus* L., *Portulacca oleracea* L., *Cerastium viscosum* L., *Euphorbia Cyparissias* L., *Convolvulus arvensis* L., *Cichorium Intybus* L.

Eastern North America. — *Erigeron annuus* (L.) Pers., *Achillea Millefolium* L., *Plantago Rugelii* Decaisne, *Barbarea Barbarea* (L.)

MacM., *Trifolium repens* L., *Lepidium Virginicum* L., *Equisetum arvense* L., *Ambrosia trifida* L., *Rhus glabra* L., *Phytolacca decandra* L., *Nabalus altissimus* (L.) Hook., *Asclepias Syriaca* L., *Oxalis stricta* L., *Onagra biennis* (L.) Scop., *Ambrosia artemisiaefolia* L., *Rhus radicans* L., *Bidens bipinnata L.*, *B. connata* Muhl., *Verbena hastata* L., *Solanum Carolinense* L., *Panicum capillare* L., *Agropyron repens* (L.) Beauv. *Polygonum aviculare* L., *P. Pennsylvanicum* L., *Amaranthus graecizans* L. (*A. albus* L.), *Convolvulus Sepium* L., *Commelina Virginica* L.

Western North America. — *Helianthus annuus* L., *Rudbeckia hirta* L.

India. — *Abutilon Abutilon* (L.) Rusby.

RUDERAL-PLANT FORMATION. — It is a difficult matter to distinguish clearly between the roadside plant formation and the ruderal plant formation, because near our large cities the conditions influencing vegetation are nearly similar along the much frequented highways and the neglected waste areas, or rubbish heaps. Ruderal areas are distinguished rather by the absence of certain plants found by the roadside and by the numerical frequency of the species, than by a difference in the component plants. The ruderal plant formation may be said to consist of those plants which will grow on rubbish heaps, or on made ground formed by ashes and other dry material representing the waste of a large city, or town. Such dumping places are found usually near the outskirts, and the material, as it settles down, is first covered with a rank growth of weeds and other coarse plants. Later such areas are divided into building lots. All of our large cities afford examples of such waste heaps and fields. The association of species depends largely on chance. It is determined by the way in which seeds, roots and other plant material are heaped together in the waste. Near Philadelphia the following plants are most abundant in the ruderal formation :

Plantago Rugelii, *Linaria Linaria*, *Daucus Carota*, *Rumex crispus*, *R. obtusifolius*, *Verbascum Thapsus*, *Arctium Lappa*, *Xanthium glabratum*, *Lactuca scariola*, *Melilotus alba*, *Carduus lanceolatus*, *Datura Stramonium*, *Datura Tatula*, *Syntherisma sanguinalis*, *Chaetochloa glauca*, *Atriplex hastata*, *Chenopodium album*, *C. anthelminthicum*, *Amaranthus spinosus*, *Cichorium Intybus*, *Melilotus officinalis*, *Trifolium hybridum*, *Lepidium Virginicum*, *Ambrosia artemisiaefolia*, *Bidens connata*, *Panicum capillare*, *Amaranthus graecizans*, *Solidago* (several species), *Aster* (several species), *Populus alba*, *Helianthus annuus*, *Citrullus vulgaris*, *Onagra biennis*.

The list of weeds that grow in waste places near Philadelphia and other large manufacturing towns of our region is not exhausted with the above enumeration. Only the commonest plants have been mentioned. In general, it may be said that the plants of the ruderal formation are coarse, tall, much-branched weeds of an ill smell and producing an abundance of easily distributed fruits and seeds. These weeds owe their presence in such abundance to the perfect means of distribution which they possess, as hooks, wings, tufts of hair, or other contrivances.

BALLAST-PLANT FORMATION. — Ballast-ground may be defined as a place where the material used to steady ships at sea, such as sand, gravel, stone, rubble and the like, is unloaded from vessels and piled up in heaps along the water's edge. The material composing ballast has been gathered from a great number of sources in a great many parts of the world, South America, Australia, Europe and India, from whence the ships have cleared. The result is that roots, stems, fruits and seeds of a heterogeneous assemblage of plants are mixed up in the ballast stuff, and when this lies exposed for some time the roots begin to grow and the seeds to germinate, until the ballast heap is covered by plants native to diverse parts of the globe. Some of these plants will appear but once. Others will remain and become adventitious.

B. CULTIVATED.

Southeastern Pennsylvania is preëminently an agricultural country. It is a country of well-kept, carefully cultivated farms. Now, however, many of the finest farms have been converted into suburban demesnes, where, dictated by the wealth and culture of the owners, large sums have been expended upon buildings and landscape improvements. For convenience and because the classification is a natural one the cultivated plant formation may be divided into the following areas:

1. Cereal-rootcrop-clover area.
2. Orchard area.

3. Vegetable-garden area, (a) Kitchen-gardens, (b) Truck-gardens.
4. Nursery area.
5. House- and garden-plant area.
6. Botanic-garden area.

These must be dismissed because an accurate and detailed description is not possible here. They are mentioned because the natural vegetation of the region has been modified and influenced by the establishment of farms, gardens and suburban parks. If a phyto-geographic chart of the region was to be constructed, such as Robert Smith has done for Scotland, all of these areas would have to be surveyed and located upon the map. In closing, the writer believes that enough has been given in this sketch to serve as an introduction to the plant geography of a region of considerable botanical interest, historic and otherwise.

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